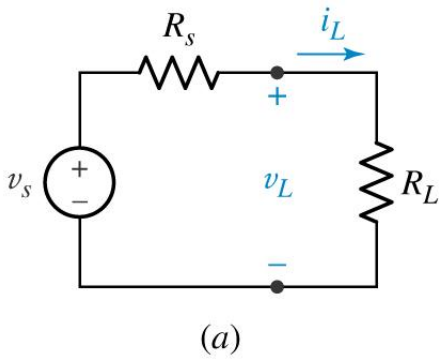
EE 101H – Electric Circuits

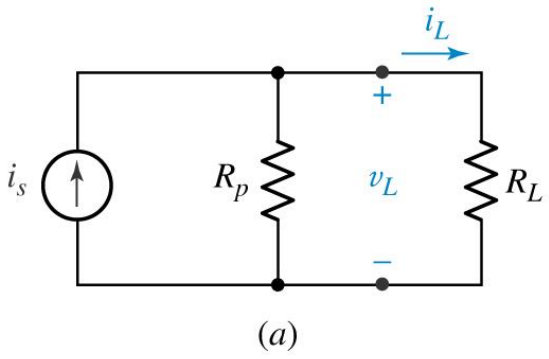
Source Transformation

And

Superposition Theorem

Source Transformation

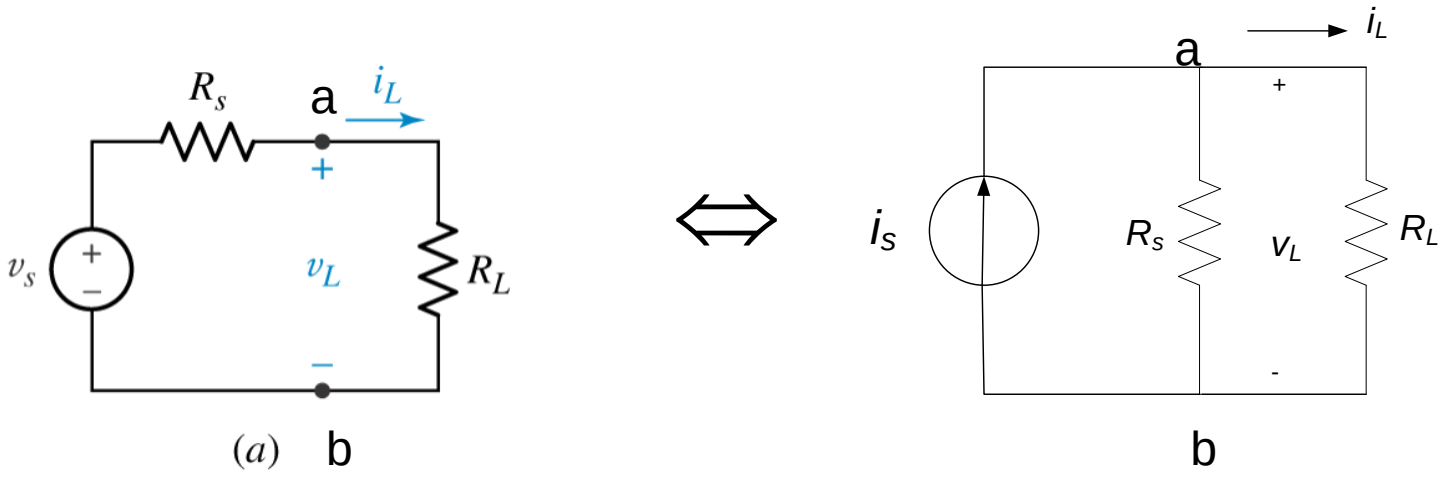




(a) A general practical voltage source connected to a load resistor R_L.

(b) A general practical current source connected to a load resistor R_L.

A source transformation allows a voltage source in series with a resistor to be replaced by a current source in parallel with the same resistor or vice versa

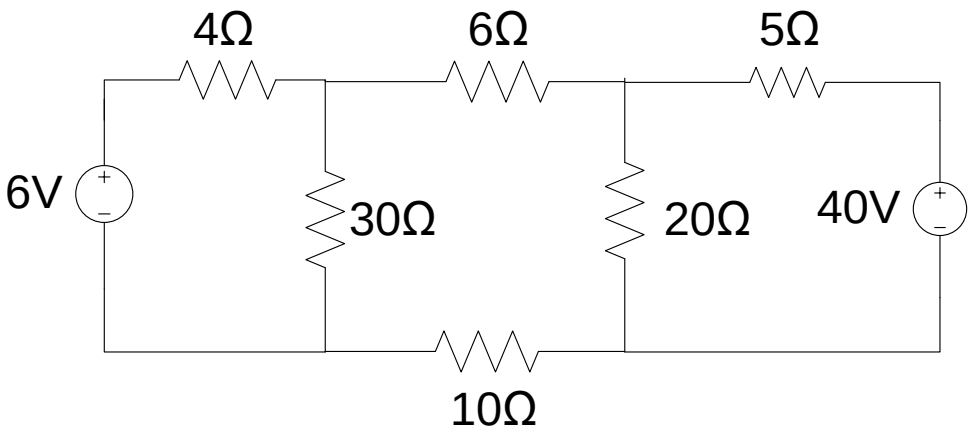


$i_s = v_s / R_s$

Suppose R_L is connected between a & b
In order the two circuits be equivalent, resistor current i_L must be same in both cases

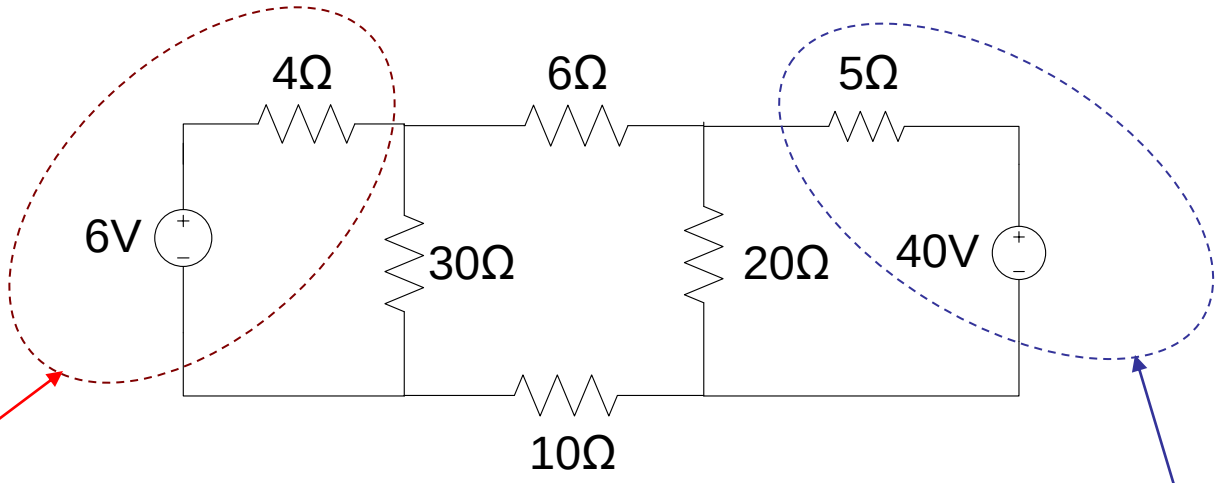
$$\frac{v_s}{R_s + R_L} = i_s \frac{R_s}{R_s + R_L} \Rightarrow i_s = \frac{v_s}{R_s}$$

Ex



Find the power associated with the 6V source using source transformation.

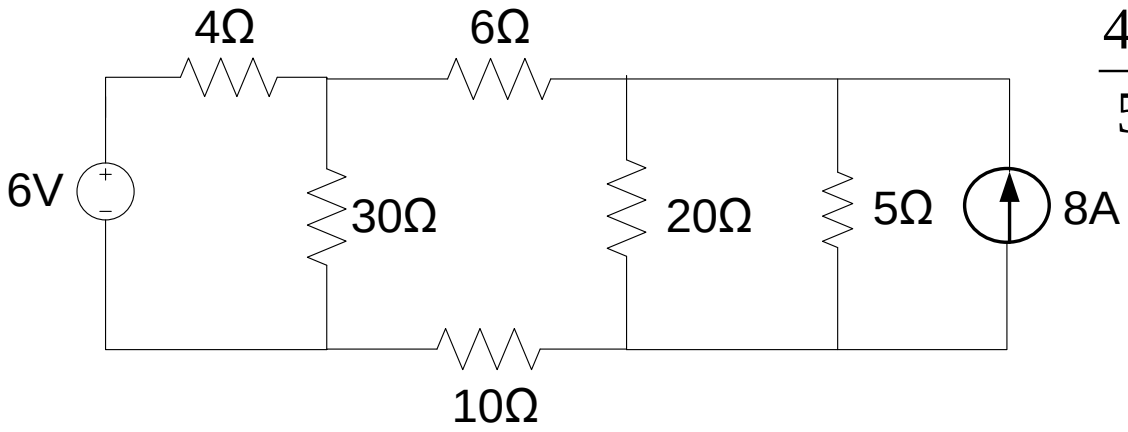
Solution



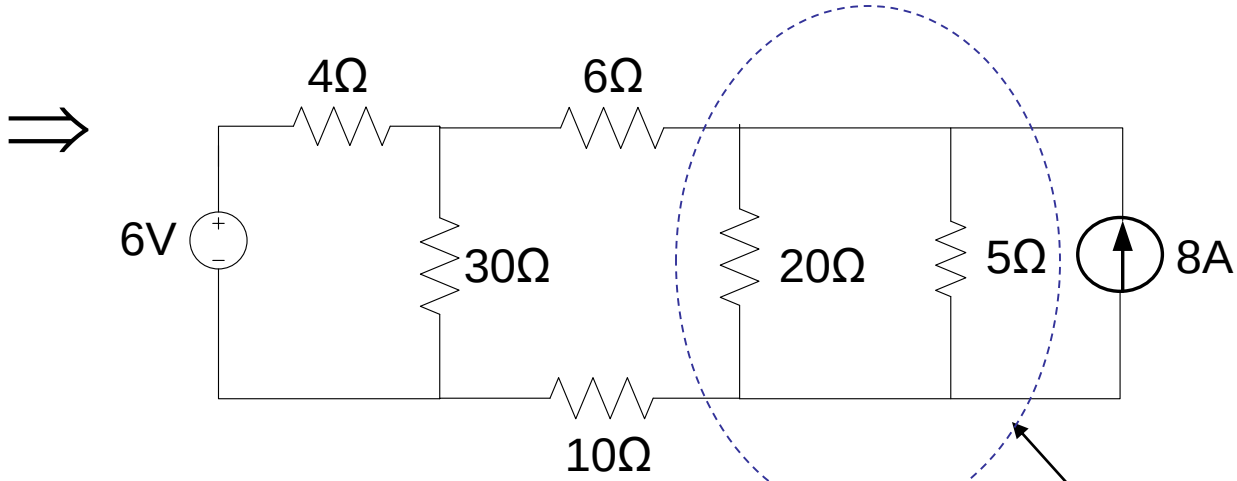
Do not disturb this part

Use source transformation

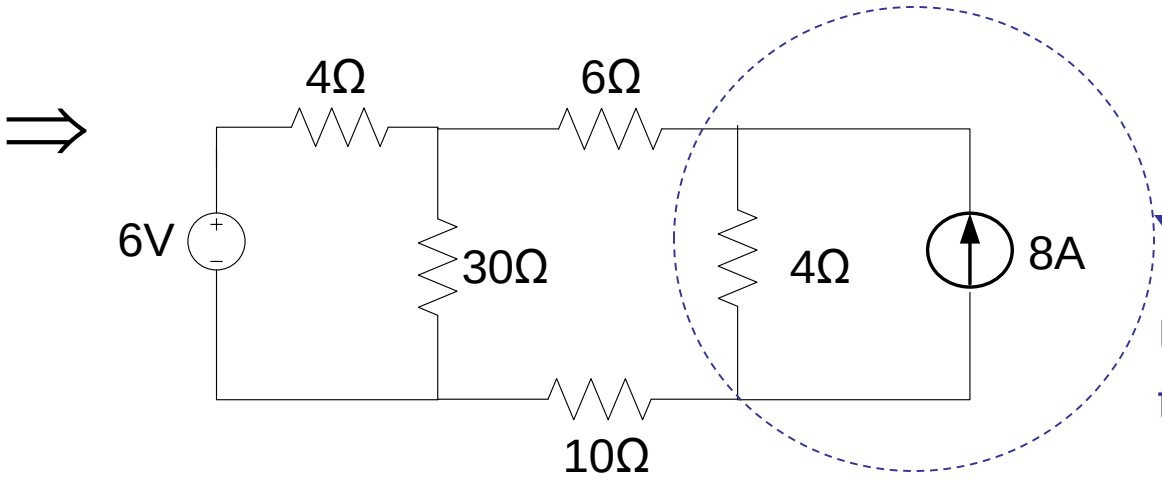
$\Rightarrow$



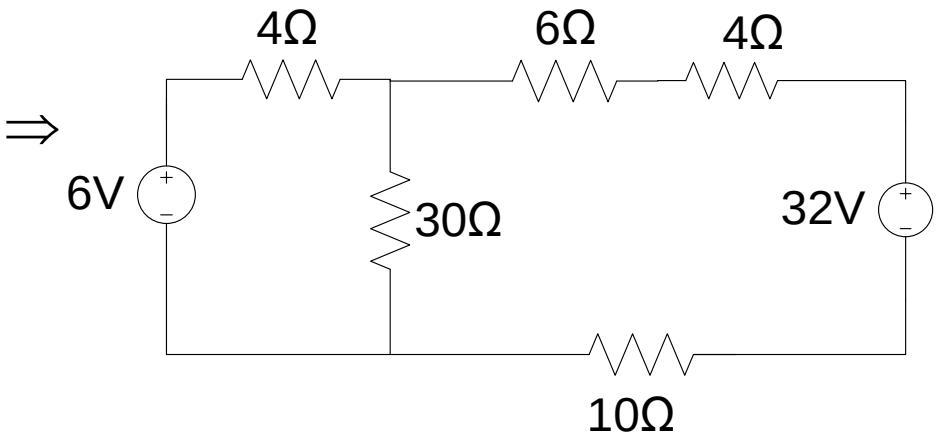
$$\frac{40\text{V}}{5\Omega} = 8\text{A}$$



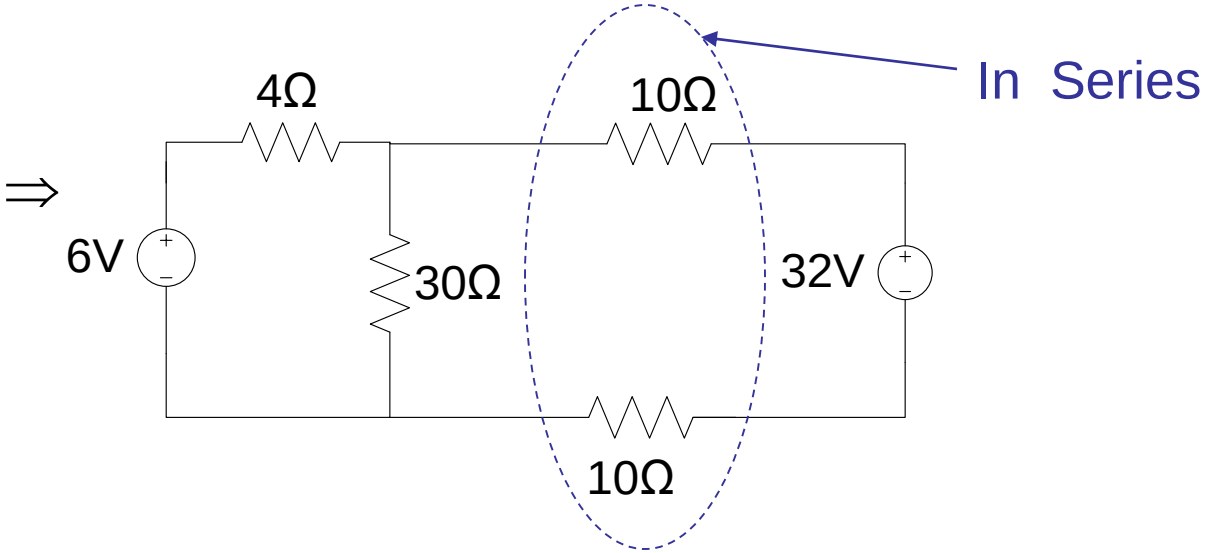
$$\frac{5\times 20}{5+20}=4\Omega$$

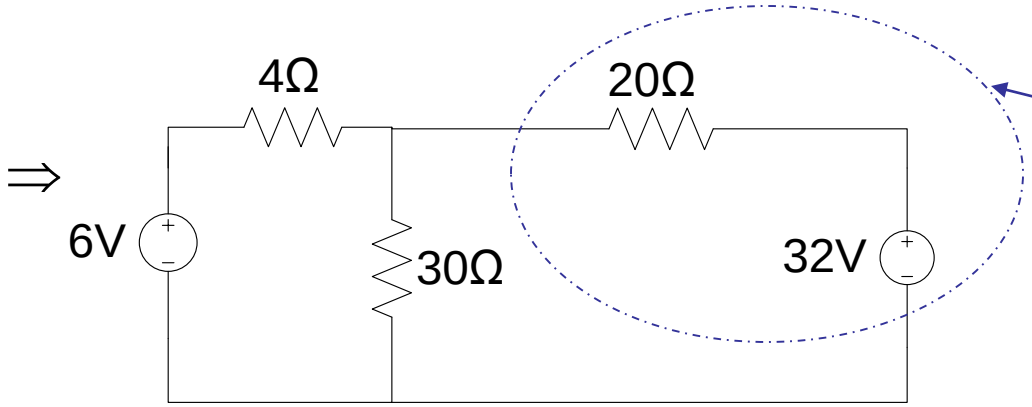


Use source transformation



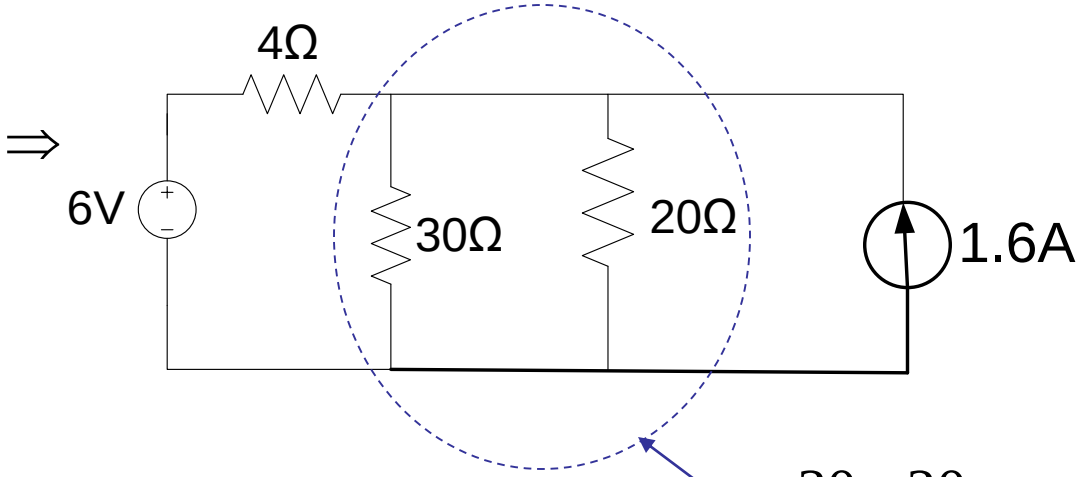
$$8\text{A} \times 4\Omega = 32\text{V}$$



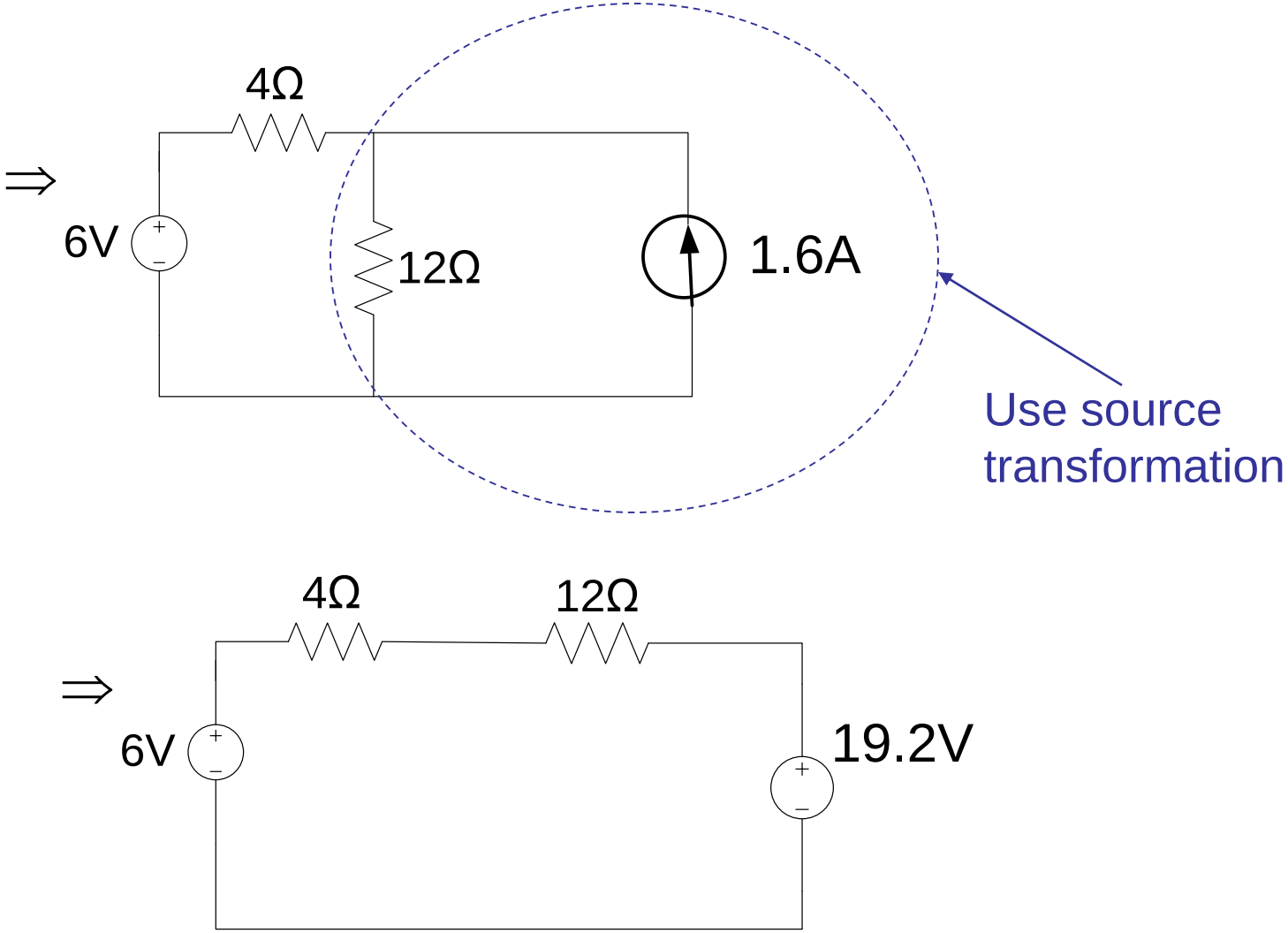


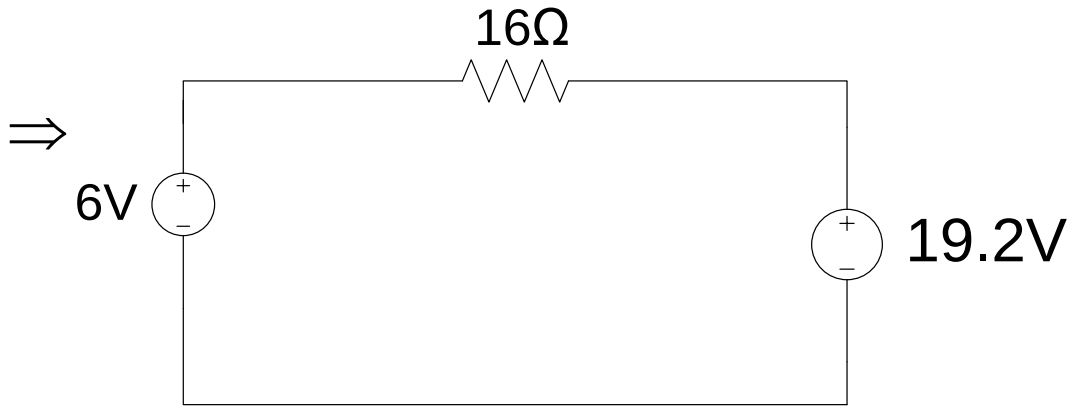
Use source transformation

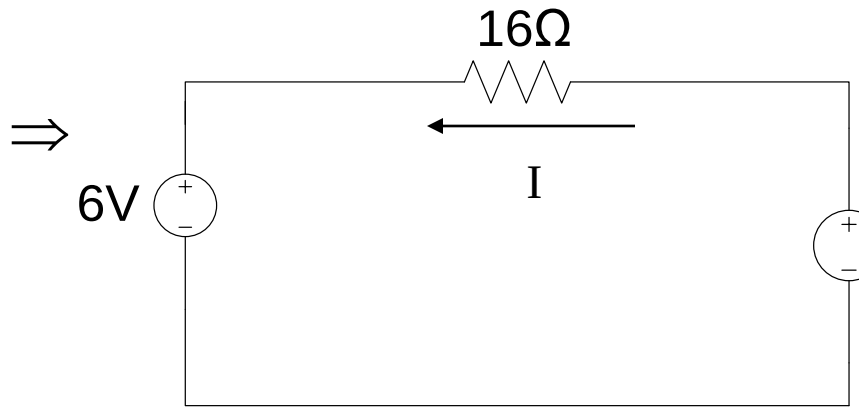
$$\frac{32\text{V}}{20\Omega} = 1.6\text{A}$$



$$\frac{30 \times 20}{30 + 20} = 12\Omega$$


4Ω
6V
12Ω
1.6A
Use source transformation
4Ω
12Ω
6V
19.2V





$$I = \frac{19.2 - 6}{16} = 0.825\text{A}$$

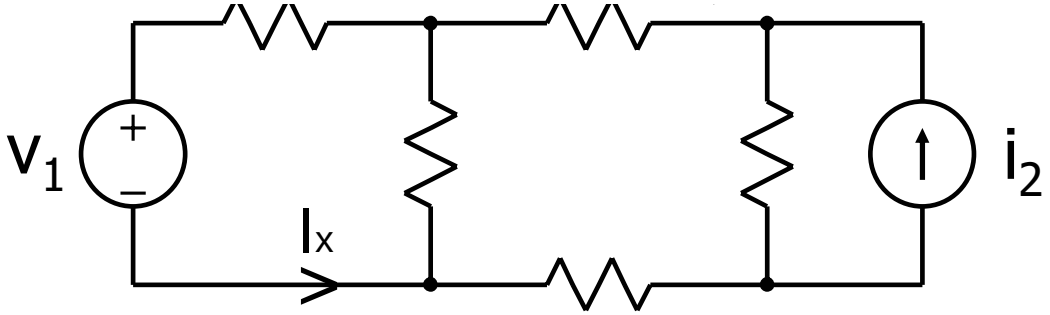
The power associated with the 6V source
= 6V × 0.825A = 4.95W
Power is +ve, absorbed

Superposition Theorem

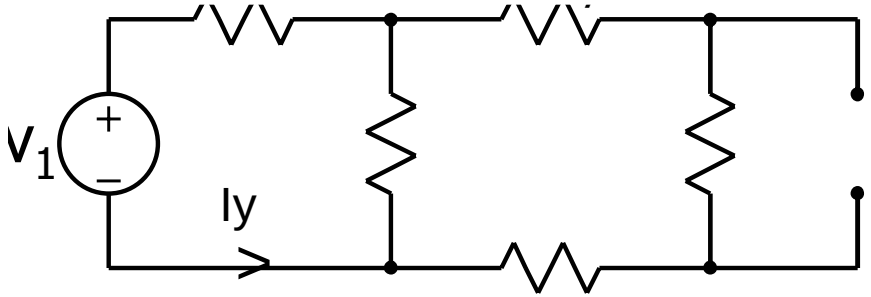
A linear system obeys the principle of superposition

It states that whenever a linear system is excited by more than one independent source of energy,
the total response is the sum of the individual responses
with all other independent sources made zero.

Find current I_x

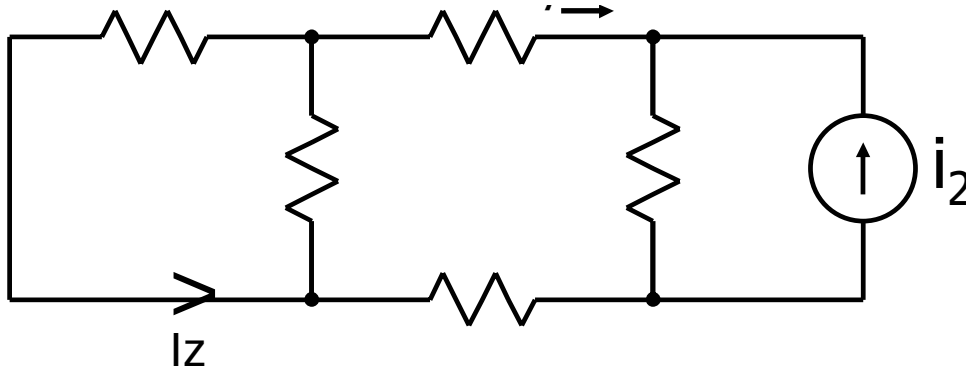


Setting $i_2 = 0$

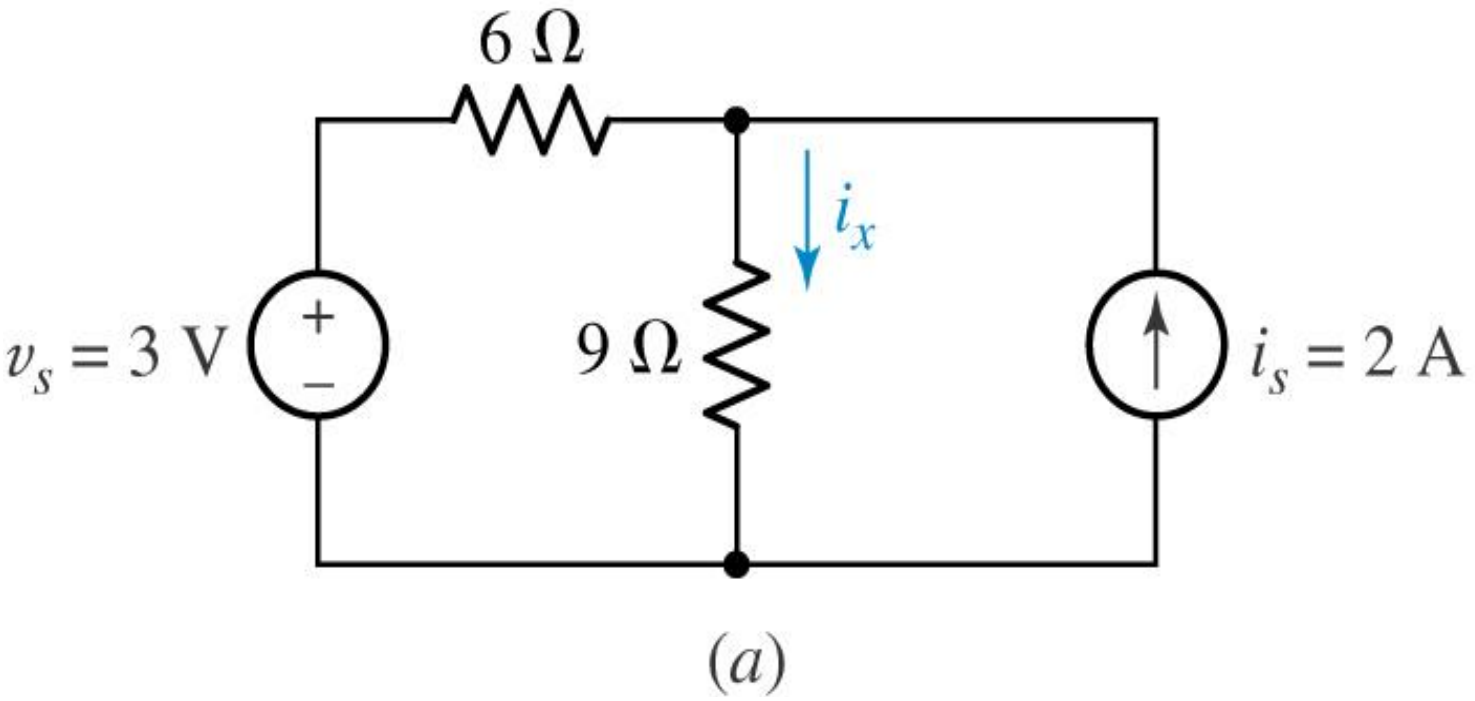


$I_X = I_y + I_z$

Setting $V_1 = 0$

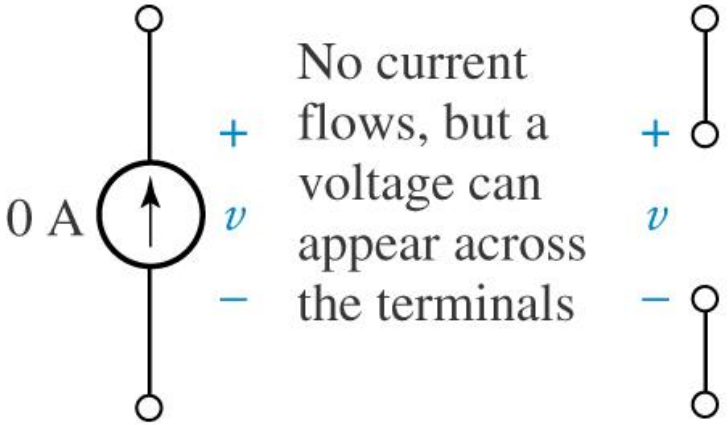


Example : Use superposition to find the current i_x



Solution

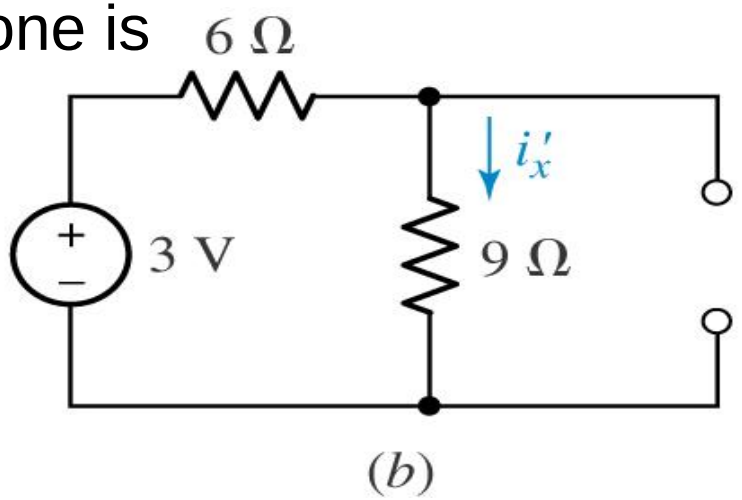
1. Find branch currents due to voltage source alone
   Replace the ideal current source by an open circuit



(a) A current source set to zero acts like an open circuit.

Current due to 3V source alone is Denoted by i_x'

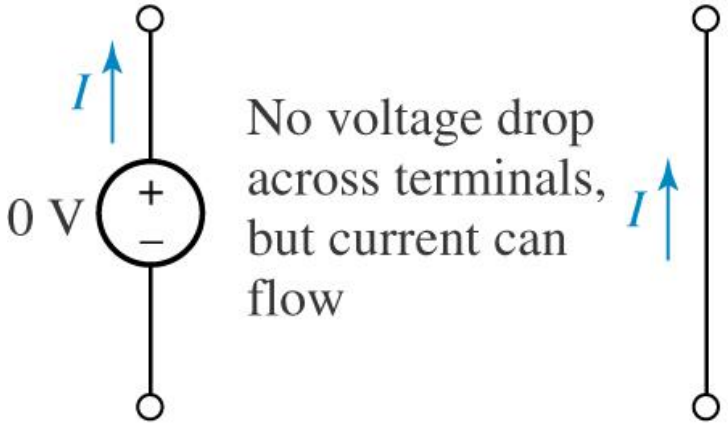
$i_x' = 3V/ (6+9)\Omega = 0.2A$



(b)

2. Branch currents due to current source alone

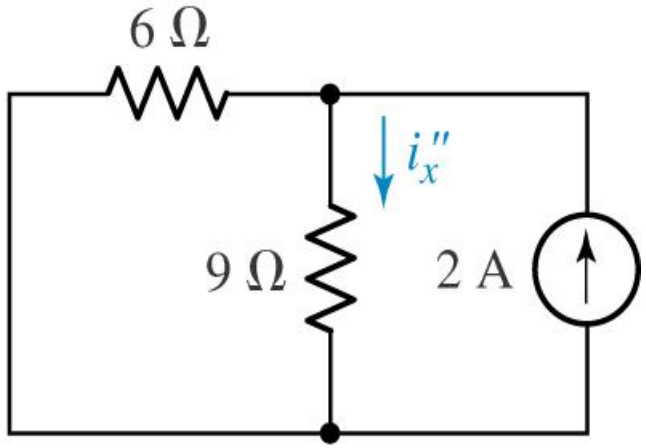
Replace the ideal voltage source by a short circuit

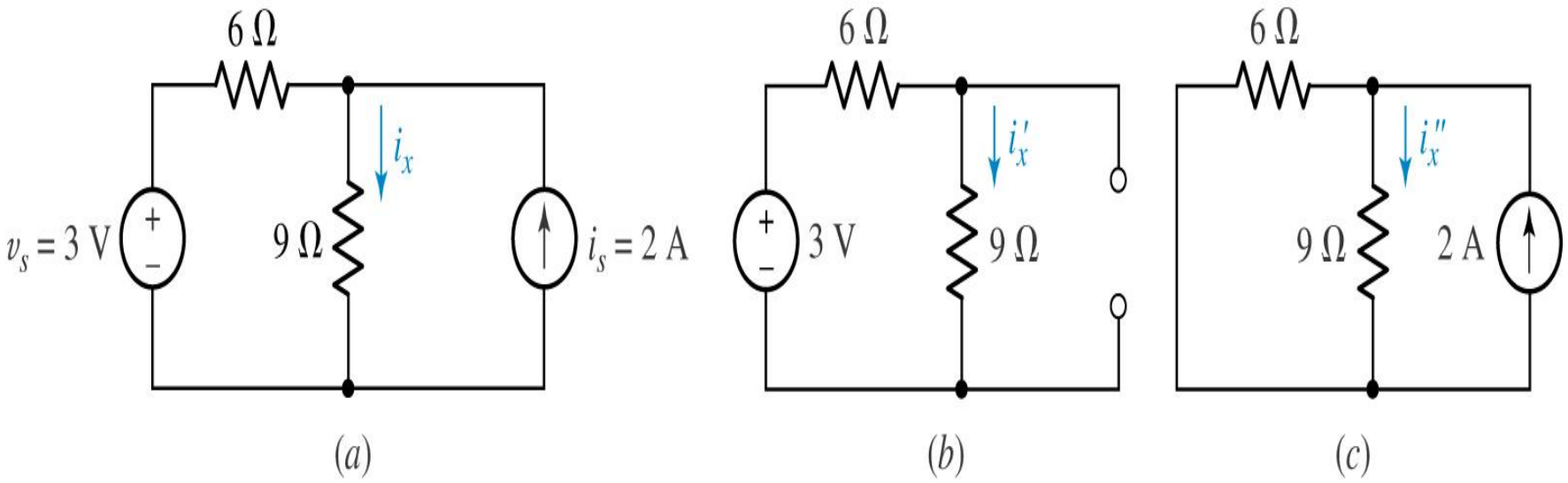


(b) A voltage source set to zero acts like a short circuit.

Current due to 2A current source alone is Denoted by i_x''

$$i_x'' = 2 \times \frac{6}{6+9} = 0.8A$$





$i_x = i_x' + i_x''$

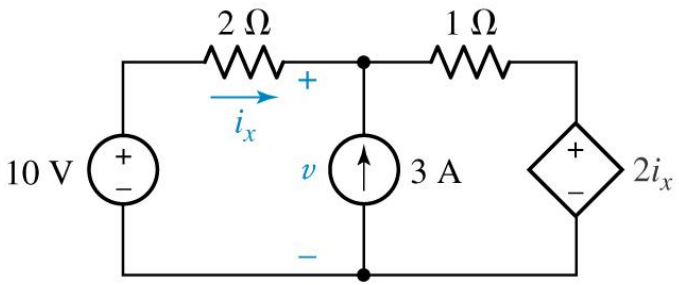
$= 0.2 + 0.8$

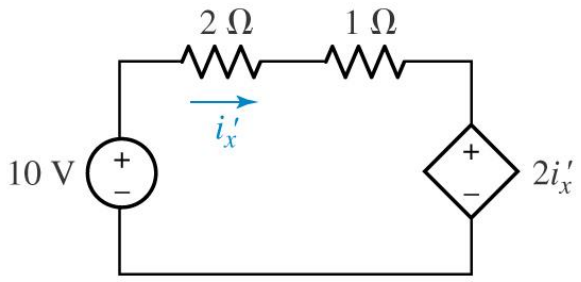
$= 1A$

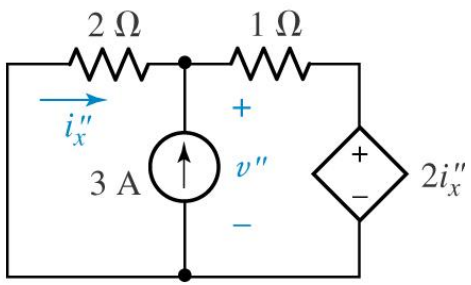
Use superposition to find the current i_x

While using superposition in linear circuits containing both independent and dependent sources, dependent sources are never deactivated

Example







Using KVL in (b),

$10 - (2+1)\, i_x' - 2\, i_x' = 0$

Or, $10 - 5\, i_x' = 0$

$i_x' = 2A$

Using KCL in (c),

$i_x'' + 3 = (v'' - 2i_x'')\,/1$

Or, $3i_x'' + 3 = v''$

Again, $v''/2 = -i_x''$

So, $3i_x'' + 3 = -2i_x''$

Or, $5\, i_x'' = -3$

Or, $i_x'' = -0.6A$

$i_x = i_x' + i_x'' = 2 + (-0.6) = 1.4A$

Feedback

- Go slow
- Move faster
- Any other?